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September 11, 2015

Mr. Mark Austin, Remedial Project Manager
American Cyanamid Superfund Site OU 8
New Jersey Remedial Branch
Emergency and Remedial Response Division
U.S. Environmental Protection Agency, Region 2
290 Broadway, 19th Floor
New York, NY 10007-1866

RE: American Cyanamid Superfund Site, Bridgewater, NJ OU8 Focused Feasibility Study Response to USEPA's July 30, 2015 Comments on the Focused Feasibility Study Work Plan Addendum – Liner Compatibility Testing for Impoundment 8 Facility CAMU Memorandum and Proposed Performance Criteria for Remedial Alternatives Memorandum for the Operable Unit 8 Pilot Study, American Cyanamid Superfund Site, Bridgewater Township, New Jersey

Dear Mr. Austin,

Wyeth Holdings LLC (WH) is in receipt of the U.S. Environmental Protection Agency's (USEPA's) letter dated July 30, 2015 providing comments on the Focused Feasibility Study Work Plan Addendum – Liner Compatibility Testing for Impoundment 8 Facility CAMU Memorandum and Proposed Performance Criteria for Remedial Alternatives Memorandum for Operable Unit 8 (OU8) at the American Cyanamid Superfund Site, Bridgewater Township, New Jersey (Site). Per previous communications, comments on the Liner Compatibility Testing have been resolved and coordination for that testing is underway. CH2M HILL, on behalf of WH, has prepared the following responses for the Performance Criteria Memorandum comments. USEPA's comments are numbered in bold text followed by italicized responses.

1. **General Comment — Regarding Hydraulic Conductivity and Unconfined Compressive Strength (UCS): Both numbers proposed are based upon laboratory values, where samples are tightly compacted into a specimen holder and allowed to cure in optimal conditions (i.e., ideal temperature and relative humidity). In previous correspondence EPA has emphasized that the field value is more critical to the success of the project. There are ASTM methods for determining final in-place hydraulic conductivity values. As a rule of thumb, also mentioned in other discussions, UCS field values are expected to likely equal 50% of the lab value.**

   Response (sent via e-mail 8/07/15): This comment refers to ASTM methods that employ field testing (as opposed to laboratory testing) for determining final in-place hydraulic conductivity and unconfined compressive strength values. Can you provide references or additional information about these ASTM field methods? We are not aware of any field methods that would be applicable.

EPA Answer (sent via e-mail 8/13/15): The point to the comment was simply that we wish to note that field measurements are much more important than any laboratory measurements.

Response: Comment acknowledged. In the absence of specific test method references the proposed performance criteria remain 1×10^{-6} cm/s for Hydraulic Conductivity and an average of 50 pounds per square inch (as measured in the laboratory) for UCS. There is no proposed change to the text, however it would be helpful to understand specific field test methods for measuring hydraulic conductivity and UCS that EPA has seen to be effective for evaluating in-situ solidification and stabilization (ISS) projects. Additional details regarding testing during implementation will be addressed during the design stage.

2. **General Comment — Leaching: Regardless of the sites identified in Attachment 1; Region II has several DNAPL sites (Gowanus Canal as example) using modified laboratory procedures (modified LEAF methods) and modeling as the leaching method.**

   Response: Comment acknowledged. The Performance Criteria memo references SPLP, ANSI 16.1 and other applicable methods, allowing for flexibility going forward as analytical methods are developed or modified. There is no proposed change to the text.

3. **General Comment - pH: Please be aware that when a large range of acceptable values (4-12) are possible it leads to a susceptible risk to amphoteric metals which can drive further risk. For example, lead will most likely be leachable unless it is in a pH range of 9-11.5.**

   Response: Comment acknowledged (pH changes can affect metals solubility and the resulting concentrations of metals in groundwater). It is important to note that metals concentrations in the untreated tar material are significantly lower than those of the organics. For example, benzene concentrations in untreated tar are on the order of 65,000 mg/kg; lead concentrations in the untreated tar material range from 10 mg/kg to 142 mg/kg (pilot test data). ISS is often used to treat metals because the selected reagents chemically stabilize the metals and prevent them from leaching. The results of the pilot test showed that lead TCLP concentrations were reduced from 0.26 mg/L (untreated tar) to <0.0065 to 0.035 mg/L following ISS; the pH of the treated material was 10-12 SU. An added benefit of ISS is that it reduces the hydraulic conductivity of the material (creates a monolith), which additionally reduces the surface area from which constituents of concern (COCs) can be leached. In summary, while the potential effect of pH on metals concentrations is acknowledged, there is no proposed change to the text.

4. **General Comment - Air Emission Thresholds: Please ensure that the F&T model is one that EPA currently endorses. Also make sure the model projects upsets in the release term which may result from a hot spot being mixed and, that the RSL includes the possibility of dermal exposure.**

   Response (sent via e-mail 8/07/15): Please clarify the term “F&T model” in this comment. We assume that F&T stands for fate and transport? Also, does “F&T model” refer to the model that *was used to estimate emissions from the material during handling or does it refer to the area wide model that was used to estimate fence line concentrations and risk?*

We would like further clarification about the request to ensure that the model "RSL includes the possibility of dermal exposure." RSLs in air represent the screening levels that are used to assess impacts from emissions; the rationale for selecting RSLs in air is that the air exposure pathway is likely to be the only potentially complete pathway. Is EPA requesting that dermal exposure to VOCs in ambient air be quantified or that direct contact with waste is a potentially complete exposure pathway and that RSLs in soil also should also be used?

EPA Answer (sent via e-mail 8/13/15): F&T is the fate and transport models being used both for source emissions and subsequent transport (dispersion, dilution, etc.). It's important to ensure that the currently endorsed model for subsequent transport by EPA is used. The actual emission model can use field emissions data.

There is potentially two types of exposure to be assessed; the first being a dermal/incidental ingestion scenario if a worker comes into direct contact with the material and, two, the more significant, the inhalation exposure from vapor and dust being emitted during handling activities. Also note that certain compounds, such as PAHs, may have a dermal exposure criteria less than the inhalation criteria, so using the lower of the two may be more appropriate, not solely the inhalation criteria.

Response: Regarding the fate and transport models, fugitive emissions will be estimated using a modification of the Jury and Eklund models (as described below) and AERMOD will be used to evaluate subsequent transport (dispersion, dilution, etc.) following release.

Fugitive emissions from an active excavation area are generated based on two primary mechanisms: 1) static vaporization (mass transfer from an open excavation face or stockpile) and 2) dynamic pore space release (active soil movement). The equations from the USEPA-endorsed Jury Model (Appendix C, Limited Validation of the Jury Infinite Source Models for Emissions of Soil-Incorporated Volatile Organic Compounds, Environmental Quality Management, Contract No. 68-D30035, July 1995) are proposed to estimate the fugitive emissions associated with the static vaporization mechanism. The Eklund model for pore space emission rates (EPA-450/1-92-004, March 1992) will be used in conjunction with the number of anticipated disturbances to estimate the fugitive emissions from the dynamic pore space release. The following modifications to the Eklund model will be applied:

- *Use Raoult's Law to take into account the multi-component system (Eklund assumed a pure component system)*
- *Assume a 100% release per disturbance (Eklund contained a "soil-gas to atmosphere exchange constant" of 0.33 or 33% release).*

As requested by USEPA, the emission model will also consider the potential for upsets that may result from a hot spot being mixed. In addition, as suggested by USEPA, emissions data from future field studies may be used to further refine assumptions used in the modeling analysis.

Regarding worker exposure (dermal/ingestion/inhalation), workers will be protected from exposure by adhering to the site-specific Health & Safety Plan (HASP). A job hazard analysis will be conducted prior to implementation of any remedy to ensure protection of human health and the environment during implementation. This analysis will consider potential dermal/incidental ingestion exposures and inhalation exposure from vapor and dust that may be emitted during handling activities.

In addition, it is recognized that risk thresholds in the range of $1x10^{-4}$ to $1x10^{-6}$ are typically applied to environmental remediation projects. For the purposes of evaluating alternatives that consider removal, analyses will be based on an assumed upper risk threshold of $1x10^{-4}$. This assumption is premised upon minimizing the duration under which treated waste transfer occurs. No additional text changes are proposed.

5. **General Comment - The performance criteria proposed in this memo represent typical performance criteria used to evaluate technologies for ISS remedies, and applies these criteria to the post-in situ pilot data results for the impoundment 2 material. This approach makes sense on one level — it is likely that the materials in impoundments 1 and 2 will undergo some in situ treatment as part of the overall remedy, since previous tests have concluded that the material cannot be handled safely ex situ in the absence of any treatment. However, using performance criteria typically used for other sites at which ISS technologies have been applied may not entirely make sense from the perspective that the unique characteristics of the materials in impoundments 1 and 2 are not likely to be similar to materials at other sites using ISS, certainly not in the concentration area. More examples of this are provided in the following comments.**

   Response: Comment acknowledged. Also, see response to General Comment No. 7 below. No additional text changes are proposed.

6. **General Comment - The memo applies the performance criteria that were identified for ISS remedies to the post-in situ pilot study material that was treated through ISS and the ISS/ISTT combination, under the assumption that this material will be left in place, and to the material that was treated only through ISS, if it is relocated to the impoundment 8 RCRA CAMU. Why wasn't the material treated only through ISTT also included in the evaluation if the material was left in place, and why wasn't the material treated through the ISS/ISTT combination as well as only ISTT included in the evaluation for relocation to the impoundment 8 RCRA CAMU. The characteristics of these other post-in situ materials should also be included in the evaluation of the performance criteria.**

   Response: As determined during the pilot test, ISTT alone would not be implemented as a standalone treatment technology for multiple reasons. The primary factors are the constructability challenges due to a lack of UCS in untreated material to support ISTT equipment *and corrosion concerns during ISTT operations. Therefore, there were no feasible scenarios envisioned where only ISTT would be employed, i.e. ISTT only and closure in place or ISTT only and relocation to the CAMU. It is for these reasons that we have assumed some form of ISS would be needed prior to ISTT.*

The proposed performance criteria for a relocation scenario include an appropriate strength (to be determined during design) and post treatment concentrations that are compatible with the liner system. These criteria would be applied regardless of treatment technology applied. The notes in Tables 1 and 2 have been modified in response to this comment and to comment #10.

7. **General Comment - Applying a 90% reduction in leachability does not result in a benzene concentration that meets TCLP requirements. Although a 90% reduction in leachability may commonly be used at other ISS sites, this reduction may allow those sites to meet TCLP requirements. It is recommended that any required concentrations associated with leachate, such as TCLP, be used to determine the percent reduction that would be required from the original benzene concentrations. This site-specific, material-specific percent reduction would be a more appropriate performance criterion for leachability.**

Response: It is recognized that the management and off-site disposal of solid waste that may be RCRA hazardous waste is centered on the use of TCLP testing methodologies. The application of TCLP however is premised upon the fundamental assumption that waste material generated (or excavated) is moved to an offsite permitted treatment storage and disposal (TSD) facility for final landfill disposal. Waste relocation affords for the collection of representative samples which can be evaluated in the laboratory using a prescribed methodology to emulate leaching characteristics after its final disposal. Although the application of TCLP values may be a convenient analog to assess remedy performance it must recognized that the testing methodologies and associated numeric standards were not developed for materials that are treated and closed in place. Materials that are closed in place retain specific structural property changes, such as greatly reduced interconnected porosity, which means that the amount of fluid (i.e. air or groundwater) that can move through the material is much lower. Consequently, TCLP based concentration standards are not applicable or representative of materials that are treated and closed-in-place.

If materials are excavated (treated or untreated) and sent for off-site treatment or disposal, then TCLP methodologies, promulgated standards and the receiving facility's requirements would dictate acceptable concentration for final disposal (e.g., TCLP, LDR)

The overall objective for closure in place is to address principle threat waste (PTW) through in-situ treatment. Specific requirements associated with treating PTW are not defined by the national contingency plan (NCP). As such, the range of preliminary alternatives assembled for OU8 afford varying degrees of treatment for PTW as measured by reduction in toxicity, mobility or volume. Treatment would be a component of every remedial alternative considered and concurrent application of engineering controls would further add to the overall protectiveness of any in place treatment closure option evaluated.

A 90 percent reduction in COC leaching from treated impoundment material would greatly improve groundwater quality downgradient of Impoundments 1 and 2. Also, as noted in the draft Technology Screening technical memorandum, application of ISS followed by in place *closure would be implemented in parallel with additional engineering controls, including a hydraulic barrier wall, which would further mitigate groundwater impacts downgradient of Impoundments 1 and 2. Additionally, the treatment standards for the material left in place must be determined in the context of the other remedial measures taken at the site. Groundwater downgradient of the impoundments is currently captured and treated by an existing extraction system, therefore there is no complete exposure pathway for groundwater. Therefore, for alternatives that include treatment and in place closure, a 90 percent reduction in leachability would be complemented by other engineering controls to ensure that the remedial alternative is protective of human health and the environment. Viewed in the context of the other remedial measures taken at the site, there is no justification for imposing a more stringent standard. No additional text changes are proposed.*

8. **General Comment - Please provide additional information on the hydraulic conductivity parameter so that EPA can evaluate its appropriateness as a performance criterion. For example, the parameter identified, 1×10^{-6} cm/s, is described as four orders of magnitude lower than the soils surrounding the impoundments. However, how does this conductivity relate to the treated material from the post-in situ study of impoundment 2? Based on the concentrations of contaminants in the treated material, what impacts would be predicted by applying this hydraulic conductivity.**

   Response: The pilot study results indicate that ISS-treated materials exhibited a hydraulic conductivity (K) of $< 1x10^{-6}$ cm/s. The relative K is a comparison between the K of the treated material and that of the surrounding soils. A lower K of the treated impoundment material relative to the surrounding soil will force groundwater to flow around the treated impoundment material through the surrounding soils, minimizing contact with COCs in the impoundment material (therefore minimizing leaching of COCs). No additional text changes are proposed.

9. **General Comment - Impoundment 8 Facility Liner Compatibility: This section states that further compatibility testing will be performed, but this section also suggests that the testing will be limited to only the ISTT-treated materials. Is this correct? Please explain why the ISS/ISTT-treated material will not also be included in the compatibility testing.**

   Response: This comment was previously addressed and USEPA subsequently approved the Bench-Scale Liner Compatibility Testing Work Plan via email on August 6, 2015.

10. **Page 2, Table 1 & Page 7, Table 2 — In regards to the Imp 8 column, "ISS & Additional Treatment" — why isn't ISTT listed here or why would it not be appropriate?**

    Response: ISTT may be considered as an additional treatment following implementation of ISS, the notes in Tables 1 and 2 have been modified to reflect this.

We trust that you will find the foregoing satisfactory. If, however, you have any questions or require further information, please contact me at 973.650.3341.

Sincerely,

Vincent D'Aco
Project Coordinator – OU8/Focused Feasibility Study

cc	Pfizer Inc	Russell Downey
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MEMORANDUM

Proposed Performance Criteria for Remedial Alternatives for Impoundments 1 and 2, Operable Unit 8, American Cyanamid Superfund Site, Bridgewater, New Jersey

PREPARED FOR:	Mark Austin/U.S. Environmental Protection Agency
COPY TO:	Michael Sivak/U.S. Environmental Protection Agency Joseph Battipaglia/U.S. Environmental Protection Agency Ed Barth/U.S. Environmental Protection Agency Russ Downey/Pfizer, Inc. Vince D'Aco/Quantum Management Group
PREPARED BY:	CH2M HILL
DATE:	June 17, 2015
REVISED:	September 11, 2015

This memorandum presents the proposed performance criteria that will be used to support development and analysis of remedial alternatives as part of the Focused Feasibility Study (FFS) for Impoundments 1 and 2 (designated as Operable Unit [OU] 8) at the American Cyanamid Superfund Site in Bridgewater, New Jersey (Site). Impoundments 1 and 2 contain acid tar, identified by the United States Environmental Protection Agency (USEPA) as principal threat waste (PTW). The conceptual remedial alternatives being considered for OU8 are based on the results of detailed laboratory- and pilot-scale treatability studies and include in-situ treatment of PTW followed by either onsite or offsite deposition. The onsite deposition endpoints include two potential response actions following in-situ treatment, specifically excavation and placement of treated material in the onsite corrective action management unit (CAMU, also known as the Impoundment 8 Facility) or closure of treated material in place.

Background

The FFS process is being used to develop, screen, and evaluate candidate remedial alternatives for OU8. Overall, the FFS process is intended to identify alternatives that will meet the remedial action objectives (RAOs) and satisfy applicable or relevant and appropriate requirements (ARARs). The following RAOs are anticipated to be included in the FFS report. These RAOs were developed based on the preliminary RAOs presented in the Revised Impoundments 1 and 2 FFS Work Plan (CH2M HILL [CH2M] 2012), which USEPA approved on September 13, 2012:

- Remove, treat, or contain material that meets the definition of PTW
- Prevent current or potential future migration of Site-related material that meets the definition of PTW from the Site that would result in direct contact or inhalation exposure
- Prevent and minimize human and ecological exposure to constituents contained in impoundment materials and within adjacent earthen berms

- Prevent and minimize sources of groundwater impacts from the impoundments resulting in long-term improvement of groundwater quality and eventual achievement of applicable regulatory criteria to the extent practicable

The RAOs listed above are preliminary and will be finalized during development of the FFS.

Performance Criteria Overview

The results of extensive bench- and pilot-scale studies have demonstrated that both in-situ solidification/stabilization (ISS) and in-situ thermal treatment (ISTT) are capable of treating impoundment materials to various treatment endpoints. This memorandum presents the key performance criteria categories that will be used to evaluate the overall ability of each remedial alterative to achieve the RAOs established within the FFS. The treatment requirements for offsite disposal are specific to individual disposal facilities and thus are well established; therefore, this memorandum focuses on performance criteria for onsite depositional endpoints following in-situ treatment, namely excavation and placement of treated material in the onsite CAMU or closure in place.

Performance criteria categories that will be used to measure an alternative's ability to achieve the RAOs for these depositional endpoints are presented in Table 1. The following sections describe the performance criteria in further detail. Additional parameters that will be evaluated, but are not considered key performance indicators (e.g., pH and air emissions), are discussed later in this document under "Other Considerations".

Table 1. Performance Criteria Overview

	Closure In Place		Impoundment 8 Facility CAMU
Performance Criteria Parameter	**ISS**	**ISS & ISTT**	**ISS & ISTT [a]**
Hydraulic Conductivity	X	-	-
Unconfined Compressive Strength	X	X	X
Leachability	X	X	-
Impoundment 8 Facility Liner Compatibility	-	-	X

"a" – Note an alternate treatment technology may be implemented instead of ISTT
X - Applicable
"-" = Not Applicable

To support the evaluation of proposed performance criteria, application of ISS among both National Priority List (NPL) and State projects similar to OU8 was reviewed. Specifically, the review was performed to identify performance criteria contained within Records of Decision (RODs) and other project documentation (e.g., 5 Year Reviews, Explanation of Significant Differences, etc.) for projects where ISS was applied for remediation of volatile or semivolatile organic compounds and PTW. In total, more than 30 sites were reviewed and about half of these had at least one performance criteria reported in the documentation. Many of these sites contain materials with PTW and/or nonaqueous phase liquid layers at the site. Almost all of these sites were located along water bodies, and many were also located near residences. A summary table presenting the results of this review is included in Attachment 1 and specific references are provided, where applicable, in the following sections.

Hydraulic Conductivity

Hydraulic conductivity of a porous medium is a function of both the physical properties of the solid matrix and the fluid passing through the medium. Hydraulic conductivity has emerged as a standard performance criteria parameter used to measure the effectiveness of ISS. The results of the literature review show that the majority of sites evaluated have established a hydraulic conductivity performance criteria for ISS (Attachment 1). The overall goal of ISS is to solidify and bind up constituents of concern

(COCs) so leachability following treatment is minimized or eliminated. One reason ISS is effective in reducing leachability is because treated materials are significantly less permeable (i.e., have a lower hydraulic conductivity), precluding contact of COCs with infiltrating stormwater or groundwater. Treatment of a wide range of materials by ISS using a variety of reagents is well documented. Despite the diverse range of materials and amendments applied, a hydraulic conductivity of 1×10^{-6} centimeters per second (cm/s) for treated material is readily achieved. A hydraulic conductivity value of 1×10^{-6} cm/s is considered the benchmark standard for ISS-based technologies.

The proposed hydraulic conductivity performance criterion for an ISS-only remedy for OU8 where treated materials are closed in place is 1×10^{-6} cm/s. This value was selected based on industry guidance documents and hydrogeologic properties of the surrounding soil. This value is consistent with performance criteria applied to other operable units at this site (i.e., OU4) and other ISS projects nationwide (Superfund and other regulatory programs), including in USEPA Region 2. As detailed in Attachment 1, 14 of the ISS projects reviewed adopted this value as the performance criteria; ISS performance criteria established at five additional sites reviewed accepted the use of a higher (1×10^{-5} cm/s) hydraulic conductivity criterion. The rationale for adopting a hydraulic conductivity performance criterion of 1×10^{-6} cm/s for an ISS-only remedy where treated materials are closed in place is supported as follows:

- The ITRC guidance document, *Development of Performance Specifications for Solidification/ Stabilization* (ITRC 2011), indicates hydraulic conductivity values of many successfully implemented ISS projects did not exceed 1×10^{-6} cm/s; therefore, this value has become an industry rule-of-thumb and best practice for implementing ISS projects.
- It is common among ISS projects to treat material such that the resulting hydraulic conductivity is one to two orders of magnitude lower than surrounding soil material (ITRC 2011). Based on the *Pre-Design Investigation for Site Wide Remedy* (Golder 2014), the hydraulic conductivity in the vicinity of Impoundments 1 and 2 is approximately 3.3×10^{-2} cm/s. By comparison, the proposed performance criteria of 1×10^{-6} cm/s is four orders of magnitude lower than that of the surrounding soil.
- The proposed hydraulic conductivity value is also consistent with the USEPA-approved ROD for OU4 at the American Cyanamid Superfund Site, which specifies a hydraulic conductivity performance criterion value of 1×10^{-6} cm/s for the selected ISS remedy. In addition, this value has been used for other USEPA-approved RODs and/or ISS designs (Attachment 1).
- The OU8 pilot study results demonstrated that the proposed hydraulic conductivity value can be obtained for post-ISS treated material.

Hydraulic conductivity is not a proposed performance criterion for alternatives where ISTT is used, since low hydraulic conductivity can inhibit the effectiveness of ISTT (depending on the specific technology application), nor is it appropriate for alternatives where treated materials are excavated under a removal scenario. It is applicable only for ISS and closure in place alternatives.

Unconfined Compressive Strength

Material strength is an important property used to assess the long-term durability of ISS-treated material. Unconfined compressive strength (UCS) is also directly related to the treated material's ability to support construction of an engineered cover, which would be required to meet the RAOs for alternatives involving a closure in place remedy. Alternatives that contemplate excavation following ISS must also consider UCS as treated materials placed in the onsite CAMU must also be capable of supporting a final cover. The parameter is also of importance for alternatives that include ISTT. Untreated material in Impoundments 1 and 2 possess limited to no UCS and, therefore, cannot support equipment or an engineered cover in their current physical state.

Specific UCS values for treated material are dependent on the specific combination of technologies implemented and the final deposition endpoints considered. Therefore, UCS performance criteria are presented below for the following three scenarios:

- ISS and closure in place
- ISS and ISTT followed by closure in place
- Alternatives involving placement of material in the CAMU

UCS Criteria for ISS and Closure in Place

The proposed UCS performance criteria for ISS only and closure in place is an average of 50 pounds per square inch (psi), with a minimum value of 40 psi, as measured at the 28-day cure. The 50 psi UCS value is an industry standard and is used as a measure of durability of the solidified matrix. This proposed UCS criteria for solidified material is also more than sufficient for supporting an engineered cover and thus meeting the RAOs for treating PTW and minimizing human and ecological exposure. The following rationale support this proposed criteria value.

- Remedy performance variability can be encountered when implemented at full-scale; therefore, it is recognized that variability in test results following a full-scale ISS approach are probable. With an ISS remedy, it is the overall aggregate performance of the treated material that is important, and some variability can be observed without compromising the success of a remedy. As such, a range of UCS measurements with an established minimum and average values is proposed.
- The proposed performance criteria for ISS only and closure in place is based in part on the ITRC (2011) guidance, which references using a 50 psi average UCS (or other site-specific value), with a minimum value of 40 psi. This approach allows for anticipated variability without compromising the success of the remedy.
- The OU8 pilot study results demonstrated that these UCS values can be obtained.
- The minimum 40 psi UCS is consistent with the value specified by the OU4 ROD for the American Cyanamid Superfund Site.
- The NPL ROD search revealed UCS performance criteria at 19 other sites that ranged from 25 to 100 psi, with the majority in the 40 to 50 psi range (Attachment 1). For the American Cyanamid Site, the 50 psi average with a minimum value of 40 psi will be sufficient to protect the remedy. For example, the minimum UCS required to support equipment during construction is approximately 20 psi, and the UCS required to support an engineered cover would be approximately 12 to 18 psi.

UCS Criteria for ISS and ISTT Followed by Closure in Place

Although the 50 psi UCS value for durability of a solidified matrix is not applicable for this alternative because there will not be a monolith but rather “soil like” material, material treated by ISS and ISTT followed by closure in place would need a minimum strength to support equipment used during remedial construction and the engineered cover following treatment. As noted above, the minimum UCS required to support equipment during construction is approximately 20 psi, and the UCS required to support an engineered cover would be approximately 12 to 18 psi. However, it is proposed that the final UCS value for ISS and ISTT followed by closure in place would be determined in the design phase (when the cap is designed and the strength requirements can be determined). Since ISS would be implemented before ISTT in this scenario, treated material is expected to exhibit sufficient strength to support the engineered cover without the need for additional stabilization following treatment.

UCS Criteria for Alternatives involving Placement of Material in the CAMU

For alternatives that involve placing treated material in the onsite CAMU, a minimum UCS value is required to ensure long-term stability and support the final engineered cover that would be placed upon closure of the CAMU. This UCS value will be based on the configuration of placed materials within the CAMU and will be determined in the design phase for the selected remedy.

According to the 1997 *Impound 8 Facility Basis of Design* (O'Brien & Gere 1997), a minimum 28-day UCS value of 42 psi (21 psi shear strength) was determined to meet the minimum factors of safety for the CAMU; however, this value was applied to material being solidified during placement and then allowed to cure in the CAMU. In addition, the 1997 value assumed a CAMU height greater than 100 feet and more than 1 million cubic yards (CY) of material placed in the CAMU. Approximately 400,000 CY of material have been placed in the CAMU to date and an additional 100,000 CY from OU8 would be placed if this alternative were selected. Because the total volume of material to be placed in the CAMU under this alternative would be less than what was assumed in 1997, the UCS requirement for placing treated materials in the CAMU is expected to be less than the 42 psi previously calculated. Therefore, it is proposed that the UCS requirement for alternatives that use the onsite CAMU be developed during design.

Methods for Determining Compliance with the UCS Criteria

For the scenarios presented above, UCS measurements will be obtained using ASTM Method D1633, *Standard Test Methods for Compressive Strength of Molded Soil-Cement Cylinders,* to evaluate if performance objectives have been met. Field measure of UCS using tools such as pocket penetrometers will be used only for collecting qualitative data as an indicator of expected curing times and not to establish quantitative performance.

Leachability

Leachability is an indicator of the potential for COCs to dissolve into infiltrating water and potentially impact groundwater. ISTT reduces leachability through mass removal, while ISS reduces leachability through a combination of mass removal, reduction in hydraulic conductivity, and contaminant sequestration. Leachability reduction is a common performance metric for ISS projects, as described by ITRC (2011). As a rule of thumb, a 90 percent reduction in COC leachability for ISS-treated material is typically adopted in establishing performance metrics for environmental remediation projects in which treated materials are ultimately closed in place. Based on a review of performance criteria identified in ISS RODs or design documents, a leachability reduction performance criterion was specified in one other site reviewed (i.e., in addition to the American Cyanamid Superfund Site) (Attachment 1). This site is located in Region 2 and had a performance criterion that specified a 90 percent reduction in leachability. Although there is not sufficient information to compare the COC concentrations for this site with OU8, this site does involve PTW and nonaqueous phase liquids (Attachment 1).

The proposed performance criterion for OU8 alternatives that include closure in place, either ISS or ISS followed by ISTT, is a 90 percent leachability reduction of benzene (which makes up at least 80 percent of the total volatile organic compound (VOC) mass and is the most soluble/mobile of the COCs). A total VOC assessment is not recommended because high detection limits are anticipated for many VOCs, which can skew the leachability calculations because of nondetect COCs. The rationale for selecting a benzene leachability reduction value of 90 percent is based on industry guidance documents, the results of bench- and pilot-scale studies, and is consistent with performance criteria applied to OU4. Note that a leachability performance criterion is not proposed for alternatives that use the CAMU for final material disposition because the CAMU incorporates robust engineering and administrative controls to manage leachate (e.g., multiple liners, leachate collection, regular monitoring, etc.).

It is recognized that the concentration of benzene in the OU8 material differs from and in some cases is greater than OU4 materials for which the 90 percent reduction in leachability criterion following ISS was established. It is also understood that 10 percent of the original leachable benzene value may still be considered of concern. However, it must be emphasized that ISS followed by closure in place in OU8 is only one component of a multifaceted remediation approach for the Site; other aspects of the remedy for OU8 will further prevent threats to human health and the environment from the benzene that may remain after ISS or ISS and ISTT, as further described below. The following rationale support this proposed performance criteria value.

- The proposed value is consistent with the site-specific performance requirements documented in the OU4 ROD for the Site.
- The proposed value is consistent with at least one other site in USEPA Region 2 for which a leachability reduction performance criterion was used.
- Application of ISS followed by closure in place would be implemented in parallel with additional features and engineering controls (e.g., cap, hydraulic barrier wall, vapor controls, etc.) to protect human health and the environment.
- Operation of the OU4 groundwater containment, extraction, and treatment system provides an added level of control and treatment for residual constituents that may leach into groundwater.
- The pilot study results showed that ISS, ISTT, and a combination of these technologies were able to achieve greater than a 90 percent reduction in leachability.

Methods for Determining Compliance with the Leachability Criteria

Leachability testing will require site-specific development during remedial design, using USEPA's synthetic precipitation leaching procedure, the ANSI/ANS 16.1 method, or other appropriate methods. The leachability reduction evaluation takes into account hydraulic conductivity to assess mass discharge from the materials pre- and post-treatment. Treatability testing will be conducted before full-scale implementation to optimize the ISS mix and demonstrate a correlation between leachability and UCS and hydraulic conductivity performance criteria.

Impoundment 8 Facility Liner Compatibility

For alternatives where treated impoundment materials will be excavated and placed in the Impoundment 8 Facility CAMU, the material being placed must be physically and chemically compatible with the CAMU liner. The concentrations of constituents in the treated pilot test materials were compared to the concentrations of other materials previously approved to be placed at the CAMU. In addition, a literature review of chemical compatibility was conducted.

A chemical compatibility evaluation was conducted on the Cell 3 and 4 liner systems as part of the 1997 basis of design (O'Brien and Gere 1997). Based on vendor information, literature review, and data collected from Cells 1 and 2, the basis of design concluded that individual concentrations of contaminants encountered at the Site are not anticipated to be a concern regarding the compatibility with geosynthetic materials.

A review of chemical resistance charts from several high-density polyethylene (HDPE) manufacturers indicates that HDPE may experience some attack from benzene (GSE 2015; INEOS 2015). Based on the concentrations of materials previously approved for placement in the CAMU and the results of pilot testing, it is expected that ISTT-treated materials from Impoundments 1 and 2 will be compatible with the Impoundment 8 Facility CAMU liner. However, to evaluate a range of potential alternatives that may involve placement of treated materials in the CAMU, it is recommended that additional compatibility testing be performed.

To assess whether the treated Impoundment 1 and 2 materials are compatible with the existing CAMU liner, bench-scale testing will be performed using leachate generated from the treated impoundment materials. A work plan detailing the proposed testing procedures will be submitted to USEPA for review.

Summary

Table 2 presents a summary of the proposed performance criteria.

Table 2. Summary of Performance Criteria Values

	Closure In Place		Impoundment 8 Facility
Performance Criteria Parameter	**ISS**	**ISS & ISTT**	**ISS & ISTT[a]**
Hydraulic Conductivity (cm/s)	$1x10^{-6}$	-	-
Unconfined Compressive Strength (psi)	50 (average); 40 (minimum)	TBD	TBD
Leachability Reduction	90%	90%	-
Impoundment 8 Facility Liner Compatibility	-	-	Pass compatibility testing

"a" – Note an alternate treatment technology may be implemented instead of ISTT
"-" = Not applicable
TBD – To be determined during detailed design to support an engineered cover

Other Considerations

While the performance criteria presented above for hydraulic conductivity, strength, leachability reduction, and liner compatibility are considered the primary criteria used to evaluate an alternative's ability to meet the RAOs, other factors must also be considered when designing and implementing the remedy. Although not specifically associated with remedy performance, pH of treated materials and air emissions associated with treating impoundment materials must also be considered. These considerations are discussed in more detail below.

pH

The pH of the tar material in Impoundments 1 and 2 is typically less than 2 standard units (SU), which is below the pH range used to determine if a liquid is noncorrosive (2 to 12.5 SU). Although USEPA does not regulate "corrosive solids", it is recognized that leachate generated by water contacting untreated acid tar may have a pH less than 2 SU. As defined by the Code of Federal Regulations (CFR) and detailed in 40 CFR §261.22, a solid waste is characteristically corrosive if a representative sample of the waste "…is aqueous and has a pH less than or equal to 2 or greater than or equal to 12.5." Therefore, it is proposed that the pH of the treated material range from 4 to 12 SU to meet the RAOs and allow for flexibility in the mix design and operations.

ISS remedies typically involve using alkaline reagents, such as cement or lime kiln dust, to achieve the primary remedial goals of reduced hydraulic conductivity, increased UCS, and reduced COC leachability. Adding alkaline reagents to achieve performance goals results in treated materials (solids) being in the alkaline range, often between 10 and 12 SU. If the circumstances and depositional endpoint of an alternative do not require the treated material to achieve all three primary goals (e.g., reduced hydraulic conductivity is unnecessary if ISS and ISTT are used or if the treated materials are excavated and placed in the CAMU), then less reagents can be used and the pH may be lower, though typically still above 8 SU. While pH is not a performance parameter for ISS remedies, it is noteworthy that an alkaline, noncorrosive, pH is expected for alternatives that involve ISS.

The following considerations are identified for pH values:

- A noncorrosive pH range (4 to 12 SU) is required for treated PTW.
- An alkaline pH range (8 to 12 SU) is anticipated for ISS-treated materials.

Air Emissions Thresholds

Emission of volatile constituents from the impoundment materials will be controlled to protect human health during implementation of the remedial action. For in-situ treatment, air emissions must be actively managed through source control (e.g., shrouded auger) and treatment (e.g., by thermal oxidation). This section presents a proposed methodology for evaluating potential air emissions during activities following treatment, specifically excavation and placement in the CAMU for those alternative that use the CAMU. These potential air emissions will be managed appropriately depending on the residual levels achieved through treatment. Achieving air emissions thresholds that are protective of human health are ARARs for implementing the remedy. The performance criteria for controlling volatile emissions is based on the 1×10^{-6} to 1×10^{-4} target cancer risk range or noncancer hazard index of 1, as described by USEPA (1991).

For alternatives that involve excavation of treated materials for subsequent ex-situ treatment or disposal, emissions associated with the ex-situ processes must also be evaluated. Air emissions, often estimated in pounds per day, are a function of the COC concentrations in the material being managed, physical/chemical characteristics of the COC (e.g., Henry's constant; air diffusion coefficient), environmental conditions (e.g., temperature), and the production rate (i.e., how many cubic yards of soil are moved each day).

Fugitive emissions will be estimated using a modification of the Jury and Eklund models (as described below) and AERMOD will be used to evaluate subsequent transport (dispersion, dilution, etc.) following release. Fugitive emissions from an active excavation area are generated based on two primary mechanisms: 1) static vaporization (mass transfer from an open excavation face or stockpile) and 2) dynamic pore space release (active soil movement). The equations from the USEPA- endorsed Jury Model (Appendix C, Limited Validation of the Jury Infinite Source Models for Emissions of Soil-Incorporated Volatile Organic Compounds, Environmental Quality Management, Contract No. 68-D30035, July 1995) are proposed to estimate the fugitive emissions associated with the static vaporization mechanism. The Eklund model for pore space emission rates (EPA-450/1-92-004, March 1992) will be used in conjunction with the number of anticipated disturbances to estimate the fugitive emissions from the dynamic pore space release. The following modifications to the Eklund model will be applied:

- Use Raoult's Law to take into account the multi-component system (Eklund assumed a pure component system)
- Assume a 100% release per disturbance (Eklund contained a "soil-gas to atmosphere exchange constant" of 0.33 or 33% release).

The emission model will also consider the potential for upsets that may result from a hot spot being mixed. In addition, as suggested by USEPA, emissions data from future field studies may be used to further refine assumptions used in the modeling analysis.

Although there is no defined concentration limit for the material being placed in the Impoundment 8 Facility CAMU (as long as it is compatible with the liner), the combination of COC concentrations and production rate must be managed so air emissions do not pose an unacceptable risk.

An air pathway assessment will be conducted to determine the combinations of production rate and COC concentrations in impoundment materials that can be handled while protecting potential receptors. Emissions to the air of volatile constituents potentially occurring during excavation and placement in the CAMU will be assessed using modeling methods presented in USEPA guidelines for conducting air pathway assessments (USEPA 1992a). The modeling methods involve emissions estimation (USEPA 1992b, 1995, 2002) and air dispersion modeling (USEPA 2004a, 2004b). These models will provide estimated concentrations in air from emissions of volatile constituents over the duration of the ex-situ process. Human health risks from these concentrations in air are estimated using risk assessment methods presented in USEPA's regional screening levels (RSL) calculator (USEPA 2015). If there is a need for modeling to support air permitting, guidelines published by the New Jersey Department of Environmental Protection (2009) will be consulted in addition to the USEPA air pathway assessment guidelines.

The output from the air pathway analysis will be used to estimate human health risks (cancer risk and hazard indices) associated with air emissions. Air dispersion modeling will identify short-term and long-term concentrations of COCs in air around the excavation and CAMU locations. The modeled concentrations in air will be estimated at receptor locations of offsite residents or workers; health risks will be estimated based on the receptor locations where the maximum concentrations in air are predicted to occur. Lifetime health risks will be estimated taking into consideration an anticipated reasonable project duration. Based on the constituents detected in Impoundments 1 and 2, the list of COCs to be included in the air pathway assessment will include 1,4 dichlorobenzene; benzene; cumene; naphthalene; and ethylbenzene. The assessment will evaluate the cumulative lifetime cancer risks and cumulative noncancer hazards for these potential constituents in air. Based on the results from the air pathway assessment, the maximum COC concentrations that will achieve the performance criteria (i.e., within the 10^{-6} to 10^{-4} target cancer risk levels or the noncancer hazard index of 1) will be identified for the material being placed in the Impoundment 8 Facility CAMU.

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Attachment 1

Attachment 1 - Record of Decision Document Review Summary for ISS Sites
Proposed Performance Criteria Memo
American Cyanamid Superfund Site, Bridgewater, NJ

	Site Name	Site Location	EPA Region	Non Aqueous Phase Liquid (NAPL)	Principal Threat Waste (PTW)	Performance Criteria			
						Hydraulic Conductivity (cm/s)	UCS (psi)	Leachability Reduction	pH
1	McColl Superfund Site (OU2)	CA, Fullerton	9	NAPL	PTW	NR	NR	NR	NR
2	Sand Springs Petrochemical Complex Superfund Site	OK, Tulsa County	6	NAPL	PTW	NR	> 25 psi	NR	7 to 12.5
3	American Cyanamid Superfund Site (OU4)	NJ, Boundbrook	2	NAPL	PTW	≤ 1 x 10^{-6} cm/s	> 40 psi	NR	NR
4	Koppers Co Ashley River Superfund Site	SC, Charleston	4	NAPL	No	≤ 1 x 10^{-5} cm/s	> 50 psi	NR	NR
5	Gowanus Canal Superfund Site	NY, Brooklyn	2	NAPL	PTW	NR	> 20 psi	NR	NR
6	South 8th Street Landfill Superfund Site	AR, West Memphis	6	NAPL	PTW	≤ 1 x 10^{-6} cm/s (avg) ≤ 1 x 10^{-5} cm/s (max)	> 50 psi (avg) > 40 psi (min)	NR	7.0 - 11.5
7	Madison Ave Former MGP Site	NY, Elmira	2	NAPL	PTW	≤ 1 x 10^{-6} cm/s	NR	NR	NR
8	North Cavalcade Street Superfund Site	TX, Houston	6	NAPL	PTW	≤ 1 x 10^{-6} cm/s	> 50 psi	NR	NR
9	NYSEG Norwich Former MGP Site	NY, Norwich	2	NAPL	PTW	≤ 1 x 10^{-6} cm/s	> 50 psi	NR	NR
10	Sheridan Disposal Services	TX, Waller County	6	NAPL	NR	NR	NR	NR	NR
11	Caldwell Trucking Site	NJ, Fairfield Township	2	NR	NR	≤ 1 x 10^{-5} cm/s	> 50 psi	NR	NR
12	American Creosote Works	TN, Jackson	4	NAPL	NR	≤ 1 x 10^{-6} cm/s	> 100 psi	NR	NR
13	OR - Suffern MGP Site	NY, Suffern	2	NAPL	NR	NR	NR	NR	NR
14	NYSEG Cortland Homer Former MGP Site	NY, Homer Village	2	NAPL	NR	NR	NR	NR	NR
15	Craig Farm Drum	PA, Parker	3	NR	NR	NR	NR	NR	NR
16	Industrial Waste Control	AR, Fort Smith	6	No	NR	NR	NR	NR	NR
17	Nease Chemical Site	OH, Columbiana and Mahoning Counties	5	NAPL	PTW	NR	NR	NR	NR
18	Niagara Mohawk (NM) – Hiawatha Boulevard - Syracuse Former MGP Site	NY, Syracuse	2	NAPL	PTW	NR	NR	NR	NR
19	PSC Resources	MA, Palmer	1	NR	No	NR	NR	NR	NR
20	Quanta Resources Corporation Site,	NJ, Edgewater	2	NAPL	PTW	≤ 1 x 10^{-6} cm/s	> 40 psi	≥ 90%	NR
21	St. Maries Creosote Site	ID, St. Maries	10	NAPL	NR	≤ 1 x 10^{-7} cm/s	≥ 30 psi	NR	NR
22	Sanford Gasification Plant	Sanford, FL	4	NAPL	NR	NR	NR	NR	NR

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						Hydraulic Conductivity (cm/s)	UCS (psi)	Leachability Reduction	pH
23	Unnamed Former MGP Site	GA, Columbus	4	NAPL	NR	$< 1 \times 10^{-5}$ cm/s (outer containment wall $< 1 \times 10^{-6}$ cm/s)	> 50 psi	NR	NR
24	MGP Site	PA, Tamaqua	3	NR	NR	$\leq 1 \times 10^{-5}$ cm/s	NR	NR	NR
25	MGP Site	WI, Burlington,	5	NR	NR	$\leq 1 \times 10^{-6}$ cm/s	> 50 psi	NR	NR
26	Unnamed Former MGP Site	GA, Macon	4	NR	NR	$\leq 1 \times 10^{-6}$ cm/s	> 50 psi	NR	NR
27	MGP Site	NH, Exeter	1	NR	NR	$\leq 1 \times 10^{-5}$ cm/s	NR	NR	NR
28	Nyack MGP Site	NY, Nyack	2	NAPL	NR	$\leq 1 \times 10^{-6}$ cm/s	> 50 psi	NR	NR
29	Waterville Gasworks Site	ME, Waterville	1	NR	NR	$\leq 1 \times 10^{-6}$ cm/s	> 30 psi	NR	NR
30	MGP Site	MA, Milford	1	NR	NR	$\leq 1 \times 10^{-6}$ cm/s	> 50 psi	NR	NR
31	MGP Site	MA, Anthol	1	NR	NR	$\leq 3 \times 10^{-5}$ cm/s	> 50 psi	NR	NR
32	Sydney Tar Ponds	Nova Scotia, Sydney	NA	NR	NR	$\leq 1 \times 10^{-6}$ cm/s	≥ 25 psi	NR	NR

Notes:
PTW - Principal Threat Waste
UCS - Unconfined Compressive Strength
NR - Not Reported
mg/kg - milligrams per kilogram
cm/s - centimeters per second
psi - pounds per square inch
ROD - Record of Decision